Chapter 4

Illex coindetii

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Abstract: *Illex coindetii* is widely distributed in the Mediterranean, from the south of Britain to Namibia in the eastern Atlantic, and in the Caribbean, Gulf of Mexico and Straits of Florida in the western Atlantic. It grows to a maximum size of 370 and 320 mm mantle length (ML) in males and females respectively although in most areas it rarely exceeds MLs of 270 and 200 mm respectively. Data from putative daily growth increments in the statolith indicate an average life span of one year. Squid hatched in spring/summer grow slightly faster than those hatched in autumn/winter. *I. coindetii* preys on fish, crustaceans and cephalopods. One group is usually predominant but this varies with prey availability, size of squid and season. In males the number of spermatophores recorded in the Needham's sac ranges from 100 to 790. In females, the number of mature eggs in the oviduct and ovaries ranges from 50 000 to 200 000 depending on body size. A total of up to 800 000 oocytes have been recorded in the oviduct and ovary of a 250 mm ML female. Mature squid are present year-round, but peaks in spawning appear to occur in the spring/summer in the Sicilian Channel and northwest Atlantic off Spain, in summer off West Africa and in autumn in the Catalan Sea. The squid remain near the seabed during daytime and migrate into the water column at night. Seasonal migrations are not well understood but there appears to be a movement from shallow to deep water between summer and winter in the Catalan Sea. The life cycle of the species is poorly understood. In the Mediterranean, there are a number of cohorts each year which overlap, making analysis difficult. The species is mostly taken as a by-catch in other fisheries.

1 Introduction

The original description of the broadtail short-finned squid lliex coindetii (Verany, 1839) was based on a specimen from the Mediterranean off Nice, France. The holotype is presumed to be missing and a mature male caught off Port Vendres, France (western Mediterranean) (42°33'30"N, 03°39'E; bottom depth 200-500 m) has been erected as a neotype (Lu 1973). A fairly consistent synonymy exists for the species, which was referred to using several different specific names during the last century (Naef 1921-1923). Since the beginning of this century the broadtail short-fInned squid has been an object of systematic as well as biological studies (Naef 1921-1923, Adam 1952, Adam 1960, Mangold-Wirz 1963, Mangold and Fioroni 1966, Clarke 1986, Arkhipkin 1989 among others). Recently, other studies have focused on the species in relation to fisheries and management (Nigmatullin and Vovk 1972, Boletzky *et al.* 1973, Sánchez 1981, 1982, 1984, 1990, Belcari *et al.* 1989, Soro and Piccinetti Manfrin 1989, Ragonese and Bianchini 1990, Ragonese and Jereb 1990, 1992, Jereb and Ragonese 1991, González *et al.* 1992a, 1992b, Tursi and D'Onghia 1992, Sánchez and Martin 1993, Jereb and Ragonese 1995). This chapter summarizes the information available on the biology and fishery of *I. coindetii* in the Mediterranean and the eastern Atlantic.

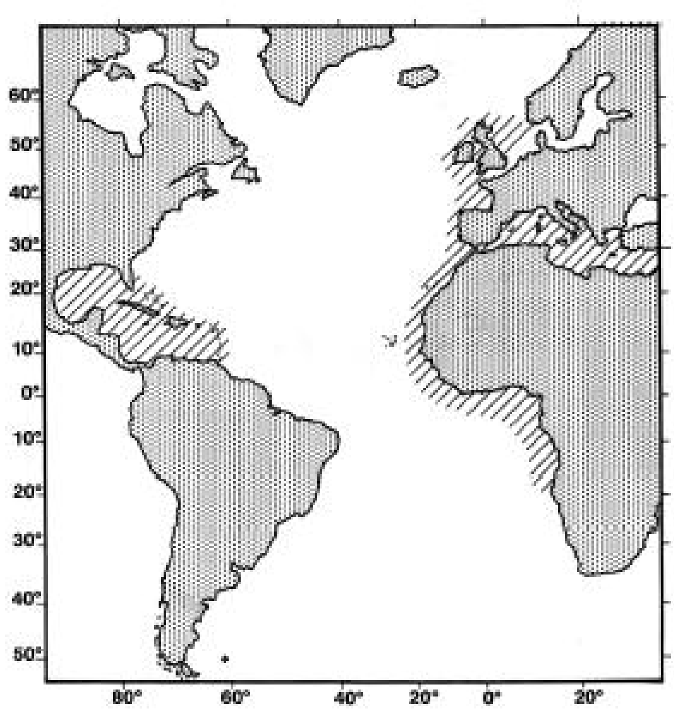

Figure 4.1 Geographic distribution of *Illex coindetii* shown by hatched area

Table 4.1. Estimated parameters a and b of relationship TW = a $\cdot TL^b$ in different areas and years; r^2 = correlation coefficient, n = number of specimens

Area	♂ a	♂ b	♂ r^2	♂ n	♀ a	♀ b	♀ r^2	♀ n
Sicilian Channel May 1985–February 1986	1.294·E-5	3.2096	0.962	1753	6.257·E-5	2.832	0.974	2096
Sicilian Channel May 1986–February 1987	1.387·E-5	3.1900	0.955	1532	7.447·E-5	2.788	0.975	1811
Catalan Sea January–December 1978	1.029·E-5	3.2385	0.945	371	2.737·E-5	2.997	0.961	416
Catalan Sea January–December 1989	3.783·E-5	3.0184	0.891	113	5.297·E-5	2.886	0.907	80
NW Spain (43°–44°N) Nov. 1991–Nov. 1992	1.793·E-6	3.567	0.947	774	444·E-5	3.099	0.969	638
NW Spain (42°–43°N) Nov. 1991–Nov. 1992	1.636·E-6	3.579	0.916	721	1.225·E-5	3.124	0.963	644
West Africa (36°N–6°S) 1967–1990	96·E-5	3.085	0.92	2425	9.58·E-5	2.705	0.95	2486

2 Geographic distribution

Illex coindetii has a wide distribution. It has been recorded throughout the Mediterranean, in the eastern Atlantic from the Bristol Channel in the British Isles, southward to Namibia, and in the western Atlantic from the Caribbean, Gulf of Mexico, and the Straits of Florida (Lu 1973, Roper *et al.* 1984, Nesis 1987) (Fig. 4.1). Some specimens have been reported from the Red Sea (Adam 1942) but these are likely to have been mislabelled (Lu 1973).

The widespread distribution of this squid, together with morphological variability throughout its range, have raised doubts as to the conspecific taxonomic status of the different populations. However, the results of a recent study to determine the systematic status of the species (*see Chapter 2*), confirm that *I. coindetii* is a single species.

3. Biological characteristics

3.1 Growth

3.1.1 Length-weight relationships

With the exception of the northwestern Spanish population, where unusually large specimens are found seasonally (up to 370 and 320 mm mantle length (ML) for females and males respectively), *I. coindetii* is a medium-sized squid, with an ML up to 250-270 mm and 180-200 mm for females and males, respectively.

Comparison of the relationship between ML (mm) and total weight (TW, g) in different regions of the Mediterranean and eastern Atlantic, as well as a comparison of different years (Sánchez 1981, Ragonese and Jereb 1992, González *et al.* 1992a, Laptikhovsky and Nigmatullin *unpubl. data*) (Table 4.1), indicate an allometric length-weight relationship which is positive in males ($b > 3$) and negative in females ($b < 3$). The one exception is females from northwestern Spanish waters (44°–42°N) where b is >3, but in this case its value is also smaller than in males. The higher value of the b coefficient in males is most pronounced during the last stages of maturation, when the relative dimensions of the head and arms lead to a distinct sexual dimorphism (Mangold *et al.* 1969).

3.1.2 Length distribution and growth

Length frequency distributions for *I. coindetii* samples from the northwest coast of Spain, the Catalan Sea (western Mediterranean) and the Sicilian Channel (central Mediterranean) are shown in Figs. 4.2, 4.3 and 4.4. Both small and large squid are present throughout the year, with no clear evidence for the presence of microcohorts. This size frequency structure makes it difficult to obtain accurate growth estimates by applying length-frequency methods conventionally used for fish and subsequently proposed for cephalopods (Pauly 1985). This has also been found by other authors (Sánchez 1984, Caddy 1991, Jackson and Choat 1992, Jereb and Ragonese 1995, González *unpubl. data*). Methods for directly estimating age based on growth increments in the statolith are thus a valuable tool for determining size-at-age.

Studies on age determination in *I. coindetii* from the Catalan Sea and from West African waters have recently been carried out using the growth increments in the statolith and with the general assumption that one increment on the statolith corresponds to one day. A study carried out on specimens from the Catalan Sea (Sánchez 1990) showed a good correlation between the number of increments and ML in both sexes. This correlation was especially high in females (Table 4.2). Two different growth groups were detected for both sexes (Fig. 4.5), depending on the hatching period. Specimens hatched in spring-summer show slightly faster growth than those hatched in autumn-winter. The maximum age estimated from increment counts was 477 days in a female of 210 mm ML.

Table 4.2. *Illex coindetii*; estimated parameters a and b of relationship $Y = a' X^b$ between number of increments of the statolith (IS) and mantle length (ML) for each sex as well as hatched in summer and hatched-in-winter groups; Vb = standard deviation of slope, r^2 = correlation coefficient, n = number of specimens

Variable Ind.	Dep.	a	b	Vb	r^2	n	Groups
IS	ML	1.8927	0.7585	0.0260	0.91	89	Winter females
IS	ML	1.5343	0.7983	0.0518	0.92	23	Summer females
IS	ML	1.8261	0.7652	0.0222	0.92	112	All females
IS	ML	0.7194	0.8943	0.0432	0.87	65	Winter males
IS	ML	0.4672	0.9827	0.0388	0.98	14	Summer males
IS	ML	0.7292	0.8940	0.0364	0.89	79	All males

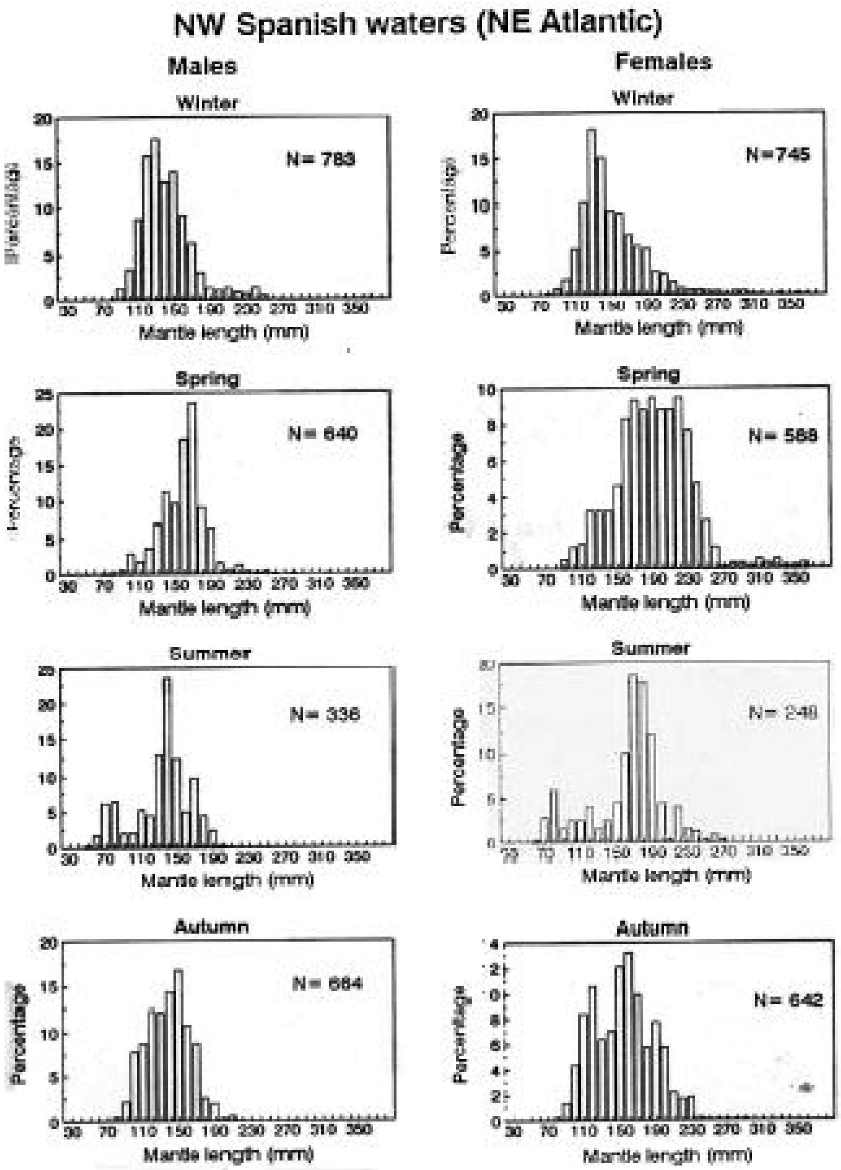

Figure 4.2. Seasonal mantle length frequency distributions of *Illex coindetii* in northwestern Spanish waters (Atlantic Ocean)

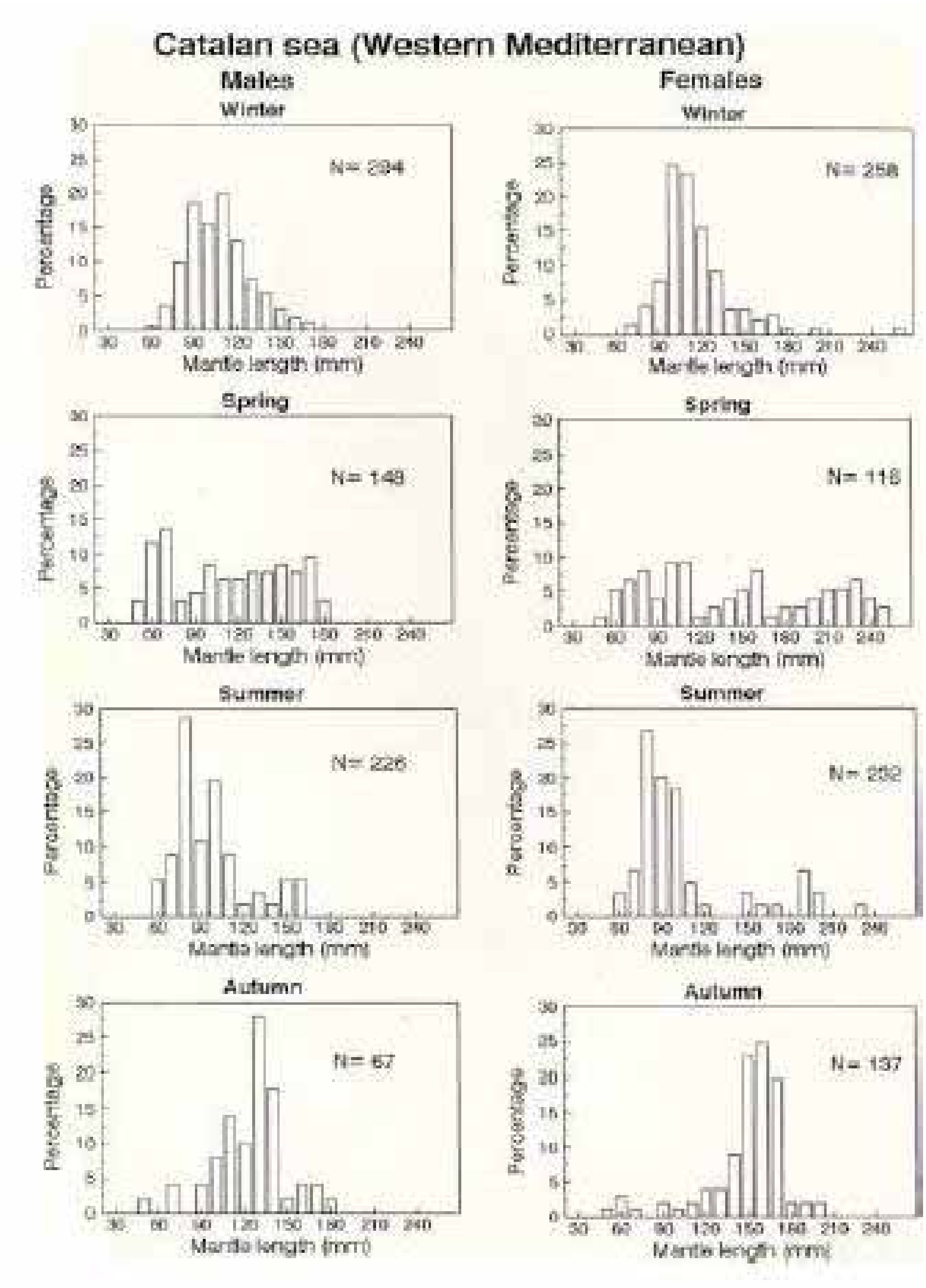

Figure 4.3. Seasonal mantle length distributions of *Illex coindetii* in the Catalan Sea (western Mediterranean)

Statolith growth-ring data from Sierra Leone and Western Sahara in the central eastern Atlantic (Arkhipkin 1989) show that relative daily growth rate (Forsythe and Van Heukelem 1987) of juveniles is c. 2 percent, which is faster than in the western Mediterranean. Nevertheless, after this early period of three to four months of rapid growth, the rate of growth decreases gradually. The maximum age estimated from number of growth increments in the central eastern Atlantic was 260-270 days in females of 290-300 mm ML. In general *I. coindetii* has a high growth rate, with females attaining a larger ML than males. The average life span is between 12 months (eastern Atlantic) and 18 months (western Mediterranean).

3.2 Feeding

Detailed infonnation on the feeding habits of *I. coindetii* have been obtained from the Catalan Sea (western Mediterranean) and from the eastern Atlantic (African waters). Three main groups of prey have been identified: fish, crustaceans and, to a lesser extent, cephalopods. These may occur together but one group is usually predominant. The dominant prey depends on prey availability, size of squid and season.

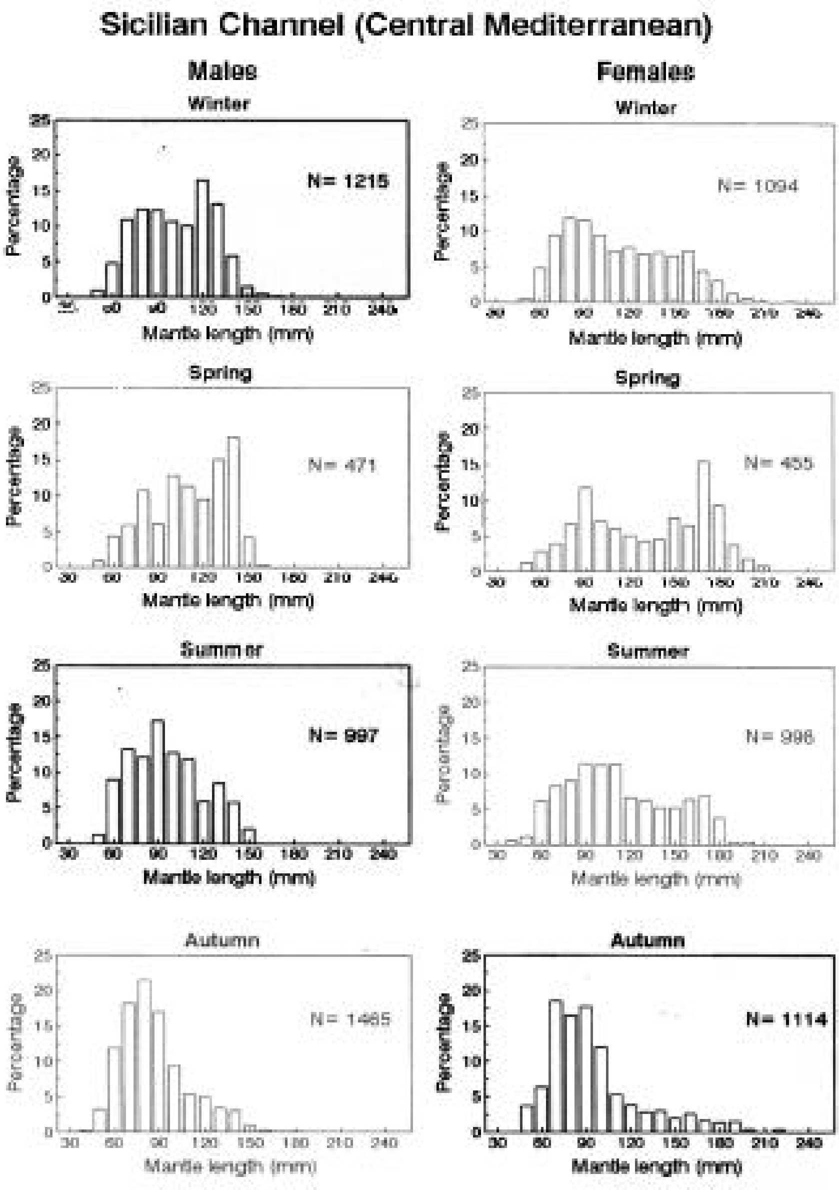

Figure 4.4. Seasonal mantle length frequency distributions of *Illex coindetii* in the Sicilian Channel (central Mediterranean)

Mud has often been found in the pallial cavity of dissected specimens, suggesting that they are caught near the sea bottom or dragged along it by the trawl. However, no organism closely linked to the sea bottom (such as polychaetes, benthic crustaceans, echinoderms or flat fish) and no grains of sand or traces of mud have ever been observed in the stomach contents of the species in the northwestern Mediterranean or in western African waters (Nigmatullin 1972, Nigmatullin and Vovk 1972, Sánchez 1982). These observations seem to confirm that although *I. coindetii* comes very close to the seabed during its daily vertical migrations, it never seeks food there but feeds mainly on prey swimming off the bottom.

Both sexes show similar dietary preferences. Fish are apparently the most preferred prey (up to 65 percent occurrence), followed by crustaceans (30 percent) and cephalopods (5 percent). Some differences in percent occurrence of the three main groups of prey have been observed in both areas, depending on the size of the squid. In the western Mediterranean small individuals (up to 90 mm ML) show an almost identical preference for fish (50 percent occurrence) and crustaceans (40 percent) with cephalopods representing 10 percent of the diet. Medium-sized specimens (100-140 mm ML) show a greater preference for fish

(66 percent occurrence) than for crustaceans (30 percent), with cephalopods still being only an occasional prey (4 percent). Larger specimens (150-250 mm ML) show a marked preference for fish (73 percent occurrence), a noticeable decrease in importance of crustaceans (21 percent), and cephalopods represent only 6 percent of the diet.

In West African waters, small *I. coindetii* (60-80 mm ML) show a marked preference for euphausiids. Fish, chaetognaths and other crustaceans occur only sporadically in the diet. Squid of medium size (100-190 mm ML) feed mainly on crustaceans and fish (up to 90 percent occurrence). Squid and tunicates represent occasional prey. Large squids (200-260 mm ML) feed mainly on fish with squid and crustaceans being of secondary importance. Occasionally euphausiids and tunicates have been found in the diet. This early shift to fish prey is pronounced and occurs at a size of 90-120 mm ML in contrast to *Illex illecebrosus* and *Illex argentinus*, in which this shift begins at the larger size of 180-220 mm ML.

Seasonal variation in the diet of *I. coindetii* has been observed in the western Mediterranean associated with abundance or shortage of particular prey. Fish generally represent the main component of the diet, followed by crustaceans and, to a lesser extent, cephalopods. The predominance of fish over crustaceans nevertheless varies according to the season. It is higher in spring, summer and autumn, varying between 60 and 75 percent occurrence, and lower in winter, when fish and crustaceans constitute 51 percent and 48 percent of the diet respectively.

These observations confinn that *I. coindetii* is mainly an opportunistic predator which generally feeds on the most abundant prey. In extreme situations it may even prey on tunicates. A consistent percentage of empty stomachs (40-65 percent) has been found among squid that have been examined, confinning the observation, made on squid held in captivity, that digestion is rapid and efficient (Boucher-Rodoni 1975). A detailed list of groups and species identified in the stomach contents of *I. coindetii* from the Catalan Sea and West African waters is reported in Table 4.3.

3.3 Reproduction

3.3.1 Sex ratio

Sex ratios observed in the Mediterranean and in the eastern Atlantic are close to 50 percent but vary slightly between areas. In the Mediterranean it varies between 46.4–46.6 percent (Sicilian Channel) and 53.2 percent (Catalan Sea). In the eastern Atlantic it varies between 43.8 percent (western African coast 16°–29°N) and 55.9 percent (West African coast 11°–15°N), High variability may result if small samples are considered independently, This variability does not seem to be linked to seasonality or bottom depth, and is more likely to be an artifact of sampling.

3.3.2 Fecundity

The number and size of spermatophores depend on the size of the squid. In *I. coindetii* males in the Catalan Sea, Mangold-Wirz (1963) found a spermatophore length of 25–35 mm for a ML between 100 and 200 mm, with an average of 250 spermatophores in the Needham's sac. For the same area, Sánchez (1981) found an average of 300–350 spermatophores in the Needham's sac. Mean length of spermatophores was 20–30 mm. In northwestern Spanish waters (42°–44°N) numbers of spermatophores in the Needham's sac have been found in the range 134–1550 (González *unpubl. data*). The largest number was observed in a male of 248 mm ML. The total number of spermatophores observed in the Needham's sac by Nigmatullin and Laptikhovsky (*unpubl. data*) in males from West African waters was usually 290–400, the largest number being 790 in a male of 176 mm ML. Spermatophore length was 14–38 (average 25) mm. Larger males produce larger spermatophores: spermatophore length varied between 18 and 35 mm for males with MLs of

113–205 mm. This agrees with the results obtained by González for the northwestern Spanish waters (*unpubl. data*). Even though spermatophore production is continuous and spermatophore number is related to the size of the animal, the number of spermatophores present also depends on sexual activity.

The number of mature eggs in the ovary and oviducts varies with female size, ranging from 50 000 to 200 000. Boletzky *et al.* (1973) and González (*unpubl. data*) estimated fecundity to be > 200 000 ova for two females of 253 g (approximately 230 mm ML) and 1 250 g (348 mm ML).

The total number of oocytes at all maturity stages in the ovary and oviducts has been reported to be up to 800 000 in a female of 250 mm ML (Nigmatullin and Laptikhovsky *unpubl. data*). The size of mature ova varies between 0.73 and 1.2 mm (Sánchez 1981, Nigmatullin and Laptikhovsky *unpubl. data*, González *unpubl. data*). The smallest ova were from African waters (7°–11°N) and the largest from the northeastern Atlantic (42°–44°N) and the northwestern Mediterranean (41°–42°N) suggesting that egg size may increase with increasing latitude.

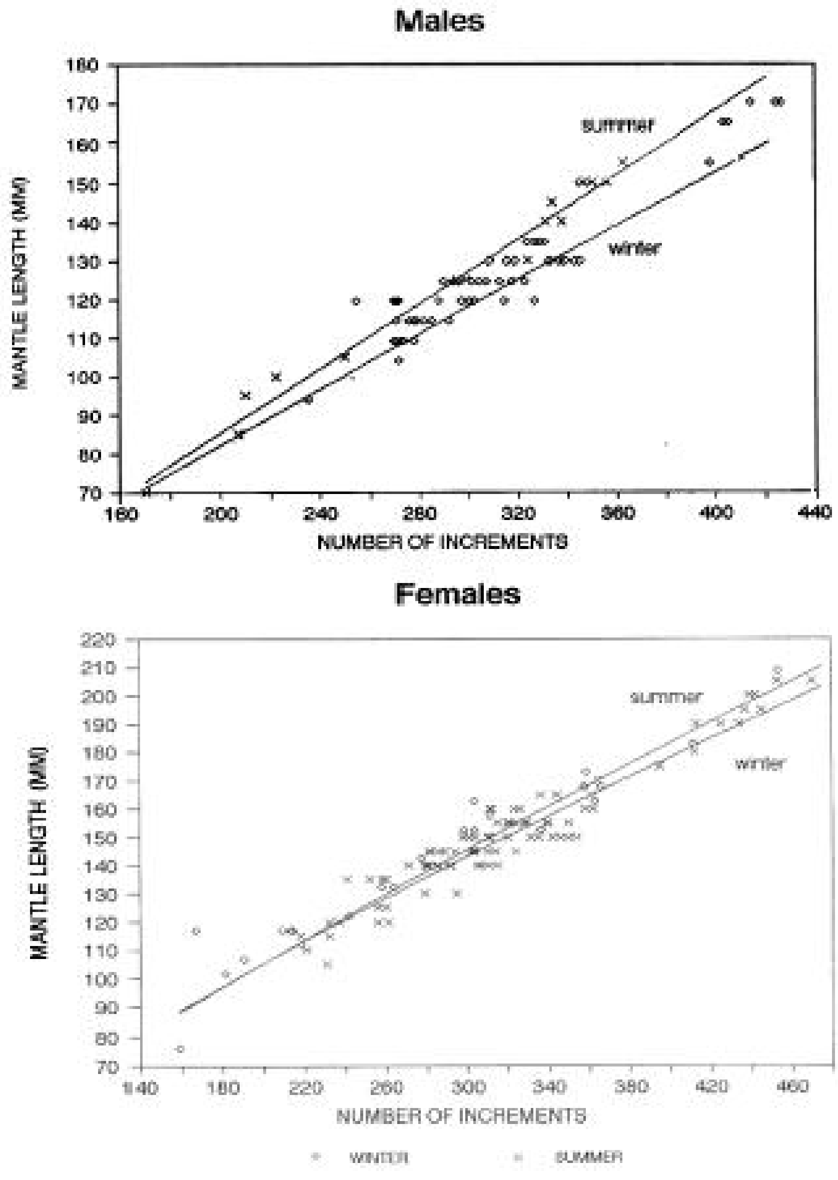

Figure 4.5. Relationship between number of increments and mantle length in males and females of *Illex coindetii* in the Catalan Sea (see Table 4.2 for equations)

Table 4.3. Composition of the diet of *Illex coindetii* in the Catalan Sea and West African waters

	Catalan Sea	Western African waters		Catalan Sea	Western African waters
CHAETOGNATHA			*Pasiphaea sivado*	*	
unidentified	–		*Pasiphaea multidentata*	*	
CEPHALOPODA			*Parapenaeus longirostris*	–	
unidentified	*		*Plesionica heterocarpus*	–	
Sepiolidae	*		*Plesionica* sp	–	
Teuthoidea	*	–	*Alpheus glaber*	*	
Todaropsis eblanae	–	*	TUNICATA		
Loligo sp	–	*	unidentified	–	*
Illex coindetii	–	*	CHORDATA		
CRUSTACEA			Pisces unidentified	*	*
Copepoda			*Antonogadus megalokynodum*		*
unidentified	–	*	*Engraulis encrasicolus*	*	–
Oncaea sp	–	*	*Sardina pilchardus*	–	*
Amphipoda			*Scomber colia*	–	*
unidentified	*		*Epigonus telescopus*	*	
Vibilia armata	*		*Gadiculus argenteus*	*	
Mysidacea			*Maurolicus muelleri*	*	–
unidentified	*		*Chlorophtalmus atlantica*	–	*
Euphausiacea			*Micromesisteus potassou*	*	–
unidentified	–	*	*Synagrops* sp	–	*
Meganectiphanes norvegica	*	*	*Sudis hyalina*	*	–
Nyctiphanes couchi	–	*	Myctophidae unidentified	*	*
Euphasia sp	–	*	Myctophum punctatum	*	
Decapoda			*Notoscopelus elongatus*	*	
unidentified	*		*Ceratoscopelus maderensis*	*	
Pasiphaea spp.	*		*Lampanyctus crocodrilus*	*	

Spermatophore bunches are attached in the mantle of females at the base of the gill near the opening of the oviduct, on the left and/or right side, depending on which arm of the male partner is hectocotylized (IV left or right). The fact that females sometimes have bunches of spermatophores on both sides of the mantle wall, and sometimes also more than two bunches (Sánchez *unpubl. data*), suggests that females may mate more than once. These bunches contain a minimum of 20 to a maximum of 950 spermatophores (Nigmatullin and Vovk 1972, Nigmatullin and Laptikhovsky *unpubl. data*), the mean value being 200–300.

The closely related species I. illecebrosus from the western Atlantic is known to be a terminal "big-bang" spawner (O'Dor 1983). In the aquarium the whole egg mass is laid within a few days. *I. coindetii* from the eastern Atlantic and the Mediterranean also seems to be a terminal spawner, but some observations suggest that the spawning period may last over a longer period (a few days to a few weeks). The number of mature eggs in the ovary and oviducts may therefore vary according to the spawning status of the individual.

Table 4.4. Mantle length (mm) of mature males and females of *Illex coindetii* in different areas

Region	Males			Females		
	Mean	Min.	Max.	Mean	Min.	Max.
Medit. 41.3°–42°N	133.4	100.0	170.0	163.9	120.0	250.0
Medit. 35°–38°N	130.1	92.5	182.5	163.1	117.5	232.5
Atlantic 43°–44°N	149.5	119.0	320.0	229.5	115.0	367.0
Atlantic 42°–43°N	129.5	93.0	230.0	189.5	105.0	325.0
Atlantic 33°–36°N	137.0	113.0	212.0	179.0	146.0	296.0
Atlantic 25°–30°N	158.0	131.0	180.0	199.0	123.0	252.0
Atlantic 21°–24°N	177.0	119.0	263.0	215.0	150.0	300.0
Atlantic 16°–20°N	156.0	95.0	220.0	194.0	162.0	250.0
Atlantic 11°–15°N	131.0	85.0	215.0	157.0	100.0	222.0
Atlantic 6°–10°N	137.0	67.0	197.0	174.0	109.0	217.0
Atlantic 6°–16°S	142.0	84.0	195.0	161.0	97.0	218.0
Average	143.7	99.9	216.8	184.1	122.2	266.3

Table 4.5. Monthly percentage of mature females of *Illex coindetii* in different areas

	Medit. 35°–38°N	Medit. 41.3°–42°N	Atlantic 42°–43°N	Atlantic 21°–24°N	Atlantic 11°–15°N	Atlantic 6°–10°N
January	–	3.8	3.0	9.1	100.0	60.0
February	22.7	0	2.4	0	27.3	–
March	–	7.1	4.5	–	3.6	2.3
April		21.4	43.7	100	9.5	8.4
May	–	52.4	39.2	100	0	62.2
June	36.7	19.2	56.3	0	4.1	13.4
July	–	3.5	83.1	71.4	–	93.3
August	27.0	25.0	75.4	25.0	83.3	
September	–	38.5	5.8	16.3	0	–
October	–	70.2	22.9	0	–	3.3
November	7.5	83.3	29.6	38.9	66.7	–
December	–	0	9.0	–	33.3	37.5

3.3.3 Spawning season

Male and female *I. coindetii* mature at a wide range of ML in all the areas investigated (Table 4.4). Nevertheless the relationship between the proportion of mature specimens as a function of ML is fitted well by the classic logistic model used for fishes (Kartas and Quignard 1984). Using data on the species in the western Mediterranean (Mangold-Wirz 1963) and in the Sicilian Channel (Jereb and Ragonese 1995), 50 percent of females were estimated to be mature at 150 mm ML and 50 percent of males at 100–120 mm ML (Jereb and Ragonese 1995).

Mature females and juveniles are found throughouthe year, suggesting year-round spawning (Table 4.5, Figs 4.2, 4.3, 4.4 and 4.6). However, seasonal peaks of spawning activity do exist and they vary with geographical area. An important peak is evident during spring and summer in the Sicilian Channel and in the northwest Spanish Atlantic. A major peak occurs in summer in the Atlantic off West Africa (11°–15°N), and in autumn in the Catalan Sea.

There is no information on paralarvae of *I. coindetii* off the West African shore. Data on capture of early juveniles of ML 20–40 mm (Morales and Guerra 1977, Nigmatullin and Laptikhovsky *unpubl. data*) and on spawning, suggests that rhynchoteuthion development occurs over the continental shelf. In the Mediterranean, four juveniles (ML= 2.6 –4.6 mm) have been caught near the Balearic Islands (Sánchez and Moll 1985).

3.4 Bathymetric movements: seasonal and daily

Illex coindetii inhabits a wide range of depths from < 50 to 800 m. In the Mediterranean the species is mostly concentrated between 100 and 350 m. In the Sicilian Channel no substantial seasonal migration has been observed (Jereb and Ragonese 1995). Juveniles and adults share the same depth range throughout the year in the Catalan Sea and Sicilian Channel, even though a major concentration of small specimens has been observed in shallower waters < 200 m) (Fig. 4.7), while large specimens are also abundant in deeper waters

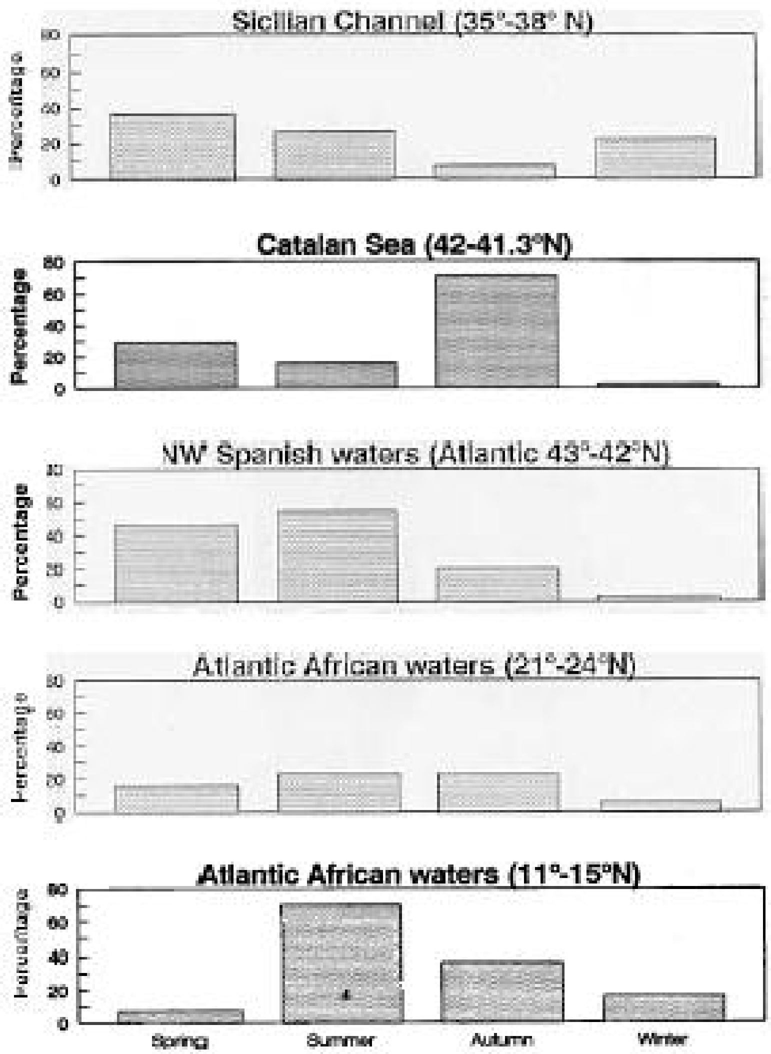

Figure 4.6. Seasonal percentage of mature females of *Illex coindetii* in different areas

(> 200 m). Seasonal migrations have been observed in the Catalan Sea. In spring the bulk of the population, including small specimens and large, mature specimens of both sexes, seek shallow water (70–150 m). Only a small percentage is found at greater depths. In summer small and medium-sized immature squid predominate between 90 and 200 m. Only at the end of summer do large mature animals and small immature specimens appear at depths > 200 m. In autumn and winter the population spreads over a wider bathymetric range (75–575 m) (Sánchez *unpubl. data*).

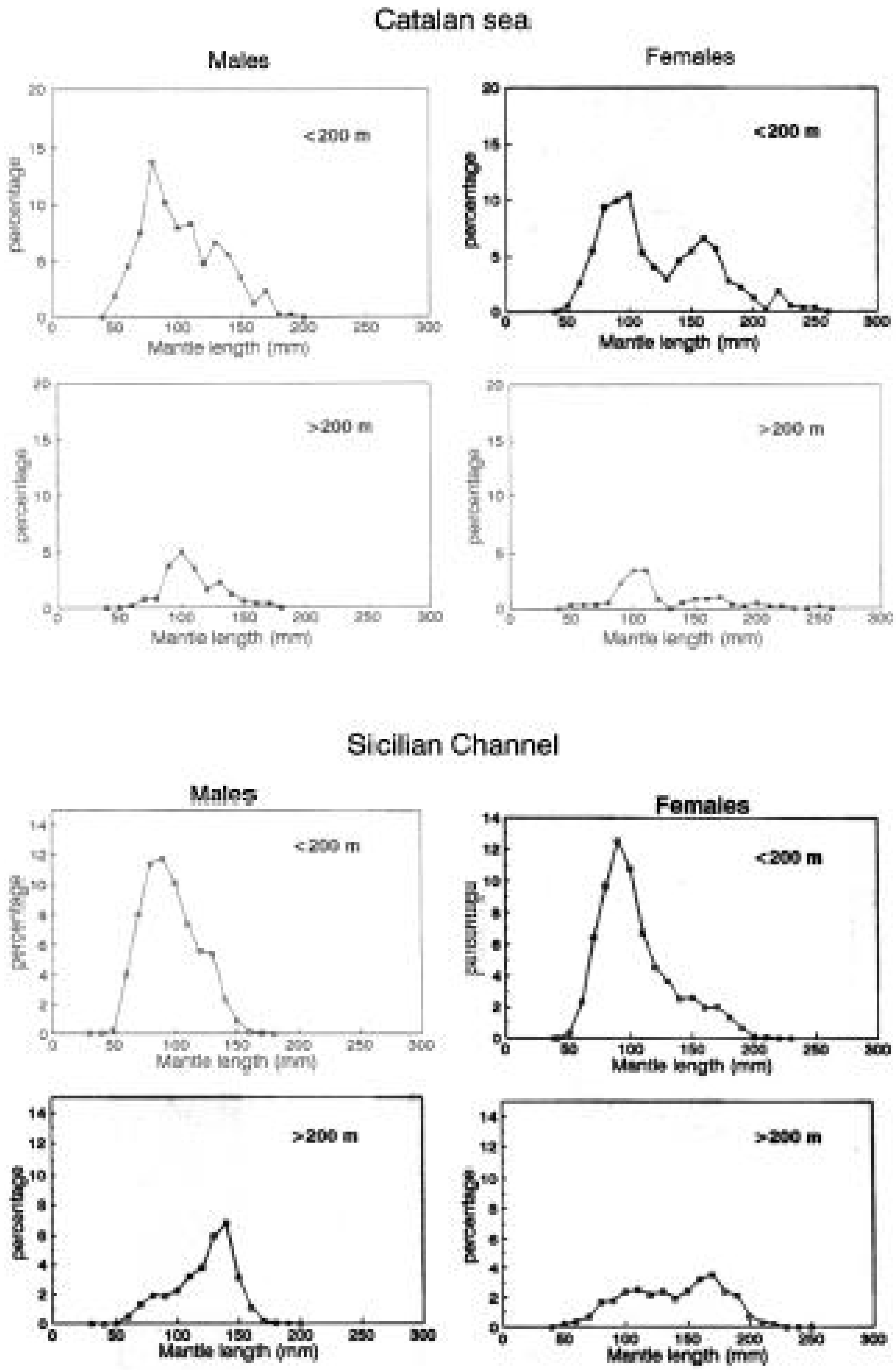

Figure 4.7. Bathymetric distribution of sizes of *Illex coindetii* by strata in the Catalan Sea and the Sicilian Channel

In the central and southeastern Atlantic, *I. coindetii* has not been recorded deeper than 550 m off Congo and Angola (Burukovsky and Froerman 1977), while in the regions off Western Sahara and Morocco it sometimes occurs at bottom depths of 750–800 m. Off northern Namibia the species does not occur deeper than 225 m. No seasonal variation in bathymetric distribution has been observed in this region. Small and large squid have been found at depths of 50–200 m. Mature squid disperse within the whole depth range, which varies with area.

The broadtail short-finned squid seems to live close to the sea bottom during the day, and undergoes vertical migrations during the night. In the Mediterranean it is frequently caught by trawlers, which operate daily from sunrise to sunset. Information on captures obtained by encircling seiners in the Catalan Sea (which work at night usually over the continental shelf) and experimental jigging at night in the Sicilian Channel (Ragonese and Bianchini 1990) confirm that migration towards the surface occurs at night.

In the Atlantic off Africa juveniles are caught near the bottom as well as in the water column. Large squid occur near the bottom during the day and at night disperse through the whole water column but remain below the subsurface thermocline (Nigmatullin and Laptikhovsky *unpubl. data*).

4 Population structure and life-history pattern

Most of the reliable information available on this topic is from the Mediterranean. No biological information exists on *I. coindetii* in the western Atlantic. The structure of a population is the result of different components of the life cycle including reproduction, recruitment, growth, mortality, dispersion and migration. It can be defmed as a year-round combination (or temporal sequence) of frequency distributions of a chosen biometrical measurement, which can be "continuous" (such as length and weight) or "discrete" (such as relative or absolute age or maturity stage).

The demographic parameters and genetic characteristics of a particular population can be derived from an age or length structure analysis of the whole population. Since in many cases it is impossible to monitor the whole population within a fishery, a representative sample of the population is usually analysed.

In *I. coindetii* from the Mediterranean the available "samples" of different populations are unfortunately only partially representative of the populations themselves. In fact they all come from experimental trawl surveys (AA. VV. 1984, Belcari *et al.* 1989, Tursi and D'Onghia 1992, Jereb and Ragonese 1995) or commercial sampling (Sánchez 1984, 1986, 1990, Sánchez and Martin 1993) carried out by trawl nets which are not selective for squid. Therefore only a preliminary account is given here. This must be considered as an indication of the population structure and life-history pattern which needs to be verified by more detailed and complete studies.

The length frequency structures of five different Mediterranean populations of *I. coindetii* (Ionian Sea, Sicilian Channel, Egyptian waters, northern Thyrrenian Sea and Catalan Sea) are compared below. Even though the gear used was not standardized in order to compare results, the effect of different selectivities on the populations sampled is negligible because of the small mesh size commonly used (Caddy 1983).

This comparison of Mediterranean populations provides evidence of a common pattern of population structure which can be summarized as follows:

a) Length classes are almost continuously represented within the ML range of the samples (between 20–30 mm and 180–200 mm for males, 240–270 mm for females, respectively).

b) Non-smoothed distributions show a characteristic saw-toothed shape with several irregular peaks. This shape becomes more regular after smoothing (as observed also for other cephalopod species, Ragonese and Jereb 1991).
c) Two main modal components which overlap each other are present or, in the case of a single mode, a "tail" is present on the left (negatively skewed) or right (positively skewed) side of the distribution.
d) In the case of a bimodal scheme, no regular seasonal variation is clearly identifiable.
e) The smaller mode, composed of juveniles, immature specimens and subadult medium-sized squid usually dominates over the mode composed of adult, mature specimens. This varies widely, but not systematically, when different areas and seasons are compared.
t) The second mode or right-hand tail of the distribution is composed mainly of adult sexually mature specimens (by mated females) and close to reproduction (spawning). This agrees well with the hypothesis of continuous reproduction through the year, even though peaks of spawning activity do exist.
g) Even though a modal progression is sometimes identifiable during the year, this cannot be supported statistically.

Following the classification of Shepherd *et al.* (1987), this characteristic structure can be defined as a "middle course" situation between the C-type population structure (multiple cohorts, also referred to as "microcohorts" for this species by Caddy 1991) and the D-type structure (multiple cohorts which overlap so much that no distinct modal component can be identified).

For the purpose of studying population dynamics this scheme is close to the typical life pattern of a species with a short life span, continuous recruitment, fast growth and high mortality: basically an "r strategy" species (Powell 1979, Pauly 1984). This is consistent with work already published on the biology of the species in the Mediterranean (Mangold-Wirz 1963, Sánchez 1981). It also agrees with results reported for the congeneric species from the Atlantic. Different biogeographic conditions may affect duration of the spawning period and of the embryonic phase, resulting in more detectable "unimodal" population structures and more perceptible modal progressions (e.g. Squires 1957, Tibbetts 1976, Mesni1 1977, Hatanaka 1986).

The observed bimodal structure for *I. coindetii* populations in the Mediterranean is of interest but it is only possible to speculate on how this arises. Growth rates might decrease greatly in mature specimens, which at the same time could become more vulnerable to fishing gear as they form mating and spawning aggregations. This might explain the increasing number of large-size specimens that constitutes the second mode or righthand tail of the distributions.

Length-frequency analysis for this species requires a long temporal series of samples of large numbers of specimens (several thousands) and a wider range of sampling methods (jigging, seine nets, and pelagic gear such as driftnets and trawls).

Due to the problems associated with applying length-frequency methods conventionally used for other resources, a direct age estimate and a better knowledge of the pattern of reproduction is necessary to verify a working hypothesis on population structure.

Due to the recent increase in interest in squid resources that have previously been considered of relatively low importance, research programs to improve knowledge on *I. coindetii* are needed to fill the present gap in knowledge for wide areas in the Mediterranean and eastern Atlantic. Information on *I. coindetii* from the western Atlantic would be most valuable and would contribute to a complete understanding of the life-history pattern of this species.

5 Fisheries

Illex coindetii is generally a by-catch of important fisheries operating within the Mediterranean and the eastern Atlantic. Official statistics are difficult to obtain because the species is often sold along with the closely related ommastrephids *Todaropsis eblanae* and *Todarodes sagittatus*. Nevertheless it constitutes a large portion of the annual catches of ommastrephid squid, and it may also be an economically important resource when large catches are landed. It is mainly caught by trawlers but it is also found in the catch from other types of gear including seiners, artisanal fisheries, longlines and jigging.

In Italian waters the only official statistics available are those from Cingolani *et al.* (1986), reporting on 2 680 t of ommastrephids landed in 1982 (0.5 percent of the total landed catch), a somewhat higher value than that reported from FAO statistics (Mangold and Boletzky 1987). Information from experimental trawl surveys in Italian waters indicates a low average yield (a few kg h^{-1}) but no commercial data are available on the species. Of the above ommastrephid landings, the main component came from Sicilian waters (2 183 t, 1.4 percent of the total landed catch in Sicily), a part of which was consistently *I. coindetii* (Ragonese and Jereb 1992).

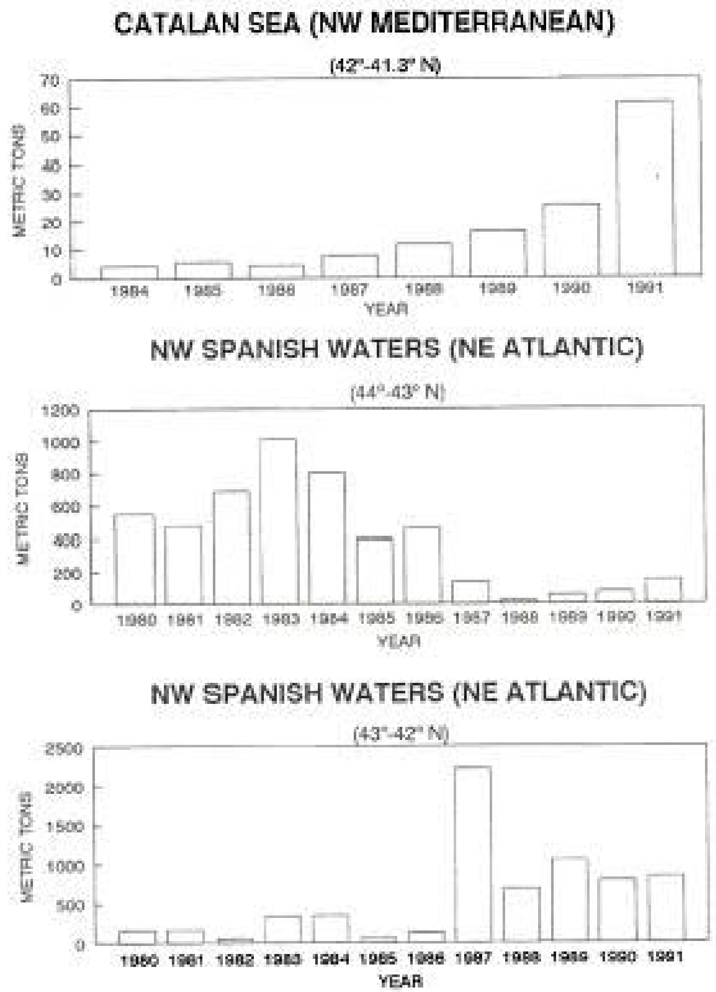

Figure 4.8. Total landings of ommastrephid squids for the period 1984–1991 in Catalan Sea (Mediterranean Sea) and for the period 1980–1991 in two areas of north-western Spain (Atlantic Ocean)

The main trawler fleet operating in the Sicilian Channel belongs to Mazara del Vallo (around 250 trawlers, from a few to 200–300 GRT). They operate in the Italian portion of the area and usually carry out long fishing trips (15–20 days). *Illex coindetii* is caught mainly by trawlers targeting Parapenaeus longirostris and Merluccius merluccius (Jereb and Ragonese 1991). Local fisheries (smaller trawlers, driftnets, seiners and small-scale fishing boats) operate in the southern Sicilian coast. They usually carry out daily fishing trips, and operate mainly on the continental shelf.

In the Catalan Sea *I. coindetii* constituted 3 percent of the cephalopod catch in 1990 (2 572 t; Sánchez and Martin 1993). The main Catalan fishing fleet consists of about 450 trawlers (average 44.2 GRT) and 200 seiners (average 20 GRT); artisanal fisheries also operate trammel nets, longlines and fishing traps (up to 1 400 small vessels, with an average 3 GRT). *Illex coindetii* is caught mainly by trawlers (98 percent of catches), but a small amount comes from artisanal fisheries (1.9 percent, mostly trammel-nets) and seiners (0.1 percent). Over the last few years an increase in the catch has been observed (Fig. 4.8): The highest monthly catch recorded (16.7 t) was in October 1991. The largest catches seasonally coincide with the time when the majority of squid are sexually mature.

In northwestern Spanish waters *I. coindetii* is taken as a by-catch by Galician trawlers. The target species are mostly *M. merluccius*, *Micromesistius poutassou* and *Nephrops norvegicus*. Fishing vessels are otter and pair (steel and wood) trawlers, 25–30 m overall length, with an average tonnage of 155 t (GRT). The fishery is carried out on local fishing grounds (100–350 m depth). Since trawlers do not have freezing facilities, they generally carry out daily fishing trips, landing fresh fish. No distinction is made between *I. coindetii* and *T. eblanae* (González et at. 1992a). Annual landings of ommastrephid squid from two areas of northwestern Spanish waters from 1980 to 1991 are shown in Fig. 4.8. Total landings range between 490 t in 1985 and 2 352 t in 1987, in both areas. Lowest landings are in summer and highest occur generally in spring and autumn. A sustained increase in catches of *I. coindetii* was observed in 1987 in northwestern Spanish waters, simultaneous with an exceptional total landing of ommastrephid squids (González et at. 1992b).

In West African waters the total abundance and concentration of *I. coindetii* is low. Catches usually do not exceed 0.5–30 kg h^{-1} (vessels of 600–1 000 GRT, Nigmatullin and Laptikhovsky *unpubl. data*). The species occurs more frequently off the coasts of Sierra Leone, Liberia, Ivory Coast and Ghana (CECAF/ECAF ser. 91/52), at depths between 50–100 and 400–700 m. *Illex coindetii* is more abundant on the Sahara Bank (18°–22°N) and in Angolan waters (6°–14°S). In these regions captures can be consistent and a specific fishery sometimes exists. For example, in Cap Blanc waters (19°–21°30'N) during the years 1974, 1982 and 1986, total squid catches reached 18 000 t (bottom depths 70–400 m). The catch consisted mainly of *T. sagittatus*, but *I. coindetii* was also consistently present (100–1 500 t per season; Nigmatullin, 1989). Off Angola, most squid concentrate between 6° and 10°S (from 70–100 m to 300 m bottom depth). *Illex coindetii* catches may reach 0.2–0.5 t h^{-1}. Sometimes, when squid concentrations are especially high in the area, a target fishery is organized and daily catches up to 3–10 t are possible. Recent estimates of *I. coindetii* biomass from the area indicate values of 25 000–30 000 t.

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